Determinants of weight gain in young women: a review of the literature

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Determinants of weight gain in young women

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Abstract:
Background: Young adult women (18-36 years) are gaining weight at rates higher than women in other age groups. Given its long term deleterious health effects, it is important to know the determinants of this weight gain. However, other than in relation to pregnancy, little is known about the determinants of weight gain in this population group. Method: Papers examining non-pregnancy weight gain in young women were identified through a literature search in PubMed in August 2008. Subsequently, reference lists of included papers were checked for additional eligible papers. Results: 29 papers were included in this review. They were grouped into five categories on the basis of the main identified determinant of weight gain: contraception (4); dietary behaviours (3); quitting smoking (1); physical activity (1) and university transition (20 papers). Study duration ranged from 13 days to 15 years. Weight was objectively measured in 25 studies and self-reported in 4 studies. 27 papers reported weight gain; the highest rates were observed with initial exposure to contraceptive use and the first semester of university. Conclusions: Even though young adulthood is a vulnerable time for weight gain in women, the number of studies examining specific determinants of weight gain was small. Those located identified five social and behavioural determinants, with most of the research focussing on the transition to and through university, and few studies in non-university populations. More studies are needed to assess the concurrent contributions of multiple determinants of weight gain at this life-stage, so that appropriate interventions to prevent excess weight gain can be developed.

Introduction

As is widely known, overweight and obesity are at record high levels worldwide, and in most western developed countries the prevalence of this problem is highest amongst people in their 50s and 60s [1]. However, in Australia, the prevalence of overweight and obesity in young adult women has also increased markedly in recent years. Between 1995 and 2005, rates increased from 16.1% to 24.8% in 18-24 year olds, and from 25.7% to 35.4% in 25-34 year olds[2]. The Australian Longitudinal Study on Women's Health (ALSWH) has reported that women in their twenties gained weight at an average rate of 630g/yr (from age 18-23 in 1996 to age 28-33 in 2006) [3]. This rate of weight gain was 30% greater than that seen in women in their forties and fifties in the same study [3]. Similar trends have been reported for young women in Europe [4, 5].

If these weight gain trends in young women continue, the problem of overweight and obesity and its associations with health problems will increase even more[6]. The resulting increases in overweight and obesity may be accompanied by increases in risk factors for many serious chronic health problems, including metabolic syndrome, diabetes and cardiovascular disease[7]. Even before they reach mid-age, young adult women may also experience additional risks to their reproductive health; overweight and obesity have been linked to infertility[8], reduced fecundity[9] and pregnancy complications, such as pre-eclampsia[10], gestational diabetes[11] and macrosomia[12]. Maternal obesity is also thought to be a precursor for childhood obesity[13]. Therefore, in addition to the detrimental effects of weight gain for young women themselves, weight gain at this life stage can also have important health implications for their offspring. Apart from their effects on well-being,

these chronic health problems will have significant economic impact, with increased costs of medical services for governments and the women themselves[6].

As pregnancy and the post-partum period have been reviewed as determinants of weight gain [14, 15] pregnancy-related weight gain was not the topic for this review. The focus was instead on the other potential underlying causes of weight gain in young women, which are not well understood. Although it is generally agreed that there is a fundamental energy balance problem [16], there have, to our knowledge, been no reviews of the factors contributing to weight gain specifically in young adult women. The aim of this paper was therefore to review the literature addressing the non-pregnancy related determinants of weight gain in young women.

Methods

Identification and selection of the literature

A literature search was carried out in PubMed (1966-August 2008), using Medical Subject Headings (MeSH) and free terms. An overview of the search process is shown in Figure 1. The search was conducted in two stages:1) a PubMed search; and 2) a search for potential papers from the references of papers identified in Stage One.

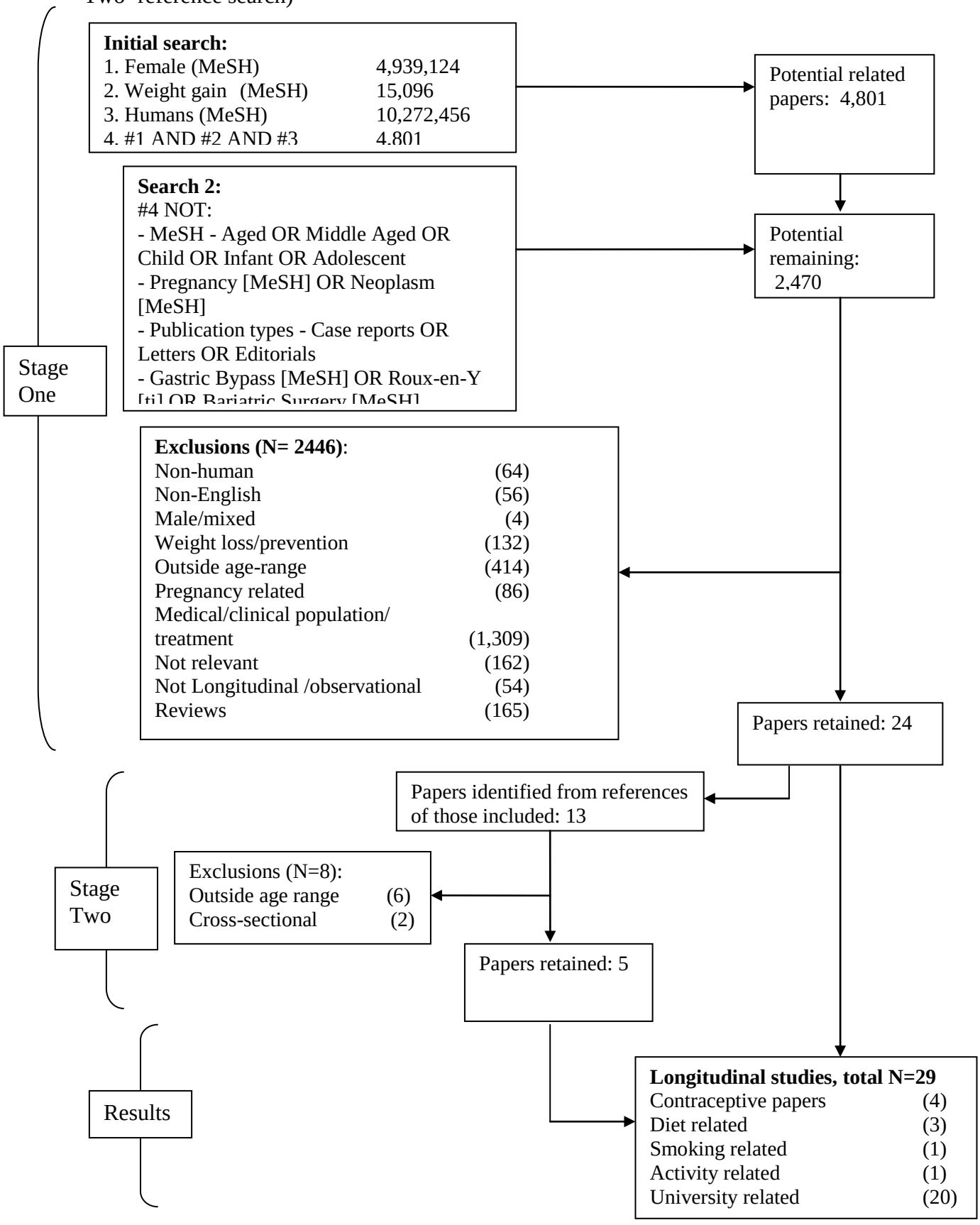
Inclusion and exclusion criteria

Full text prospective observational studies that were written in English and addressed weight change in young women were included. The following inclusion criteria for age were used: 1) *average* baseline age for participants of 18-36 years; and 2) upper limit for

the baseline age *range* of 44 years (this is the upper limit from the definition of 'adult' used in PubMed's MeSH dictionary).

Studies that included mixed sex or age samples were included only if results for young adult women were presented separately. Studies of clinical populations and weight loss programs or surgery were excluded.

Figure 1: Overview of the search process. (Stage One=PubMed search; Stage Two=reference search)



Results

A summary of the search process is shown in Figure 1. Almost 2,500 papers were initially identified in Stage One. More than half were ineligible as they focussed on treatment studies with clinical populations. The most common additional reasons for exclusion were that: participants were outside the defined age range (the majority focussed on children/adolescents or middle-aged adults); or the studies reported on evaluations of weight loss strategies. Only 24 papers met the inclusion criteria for this review. There was no overlap between the review papers identified in Stage One and this review, as those reviews focussed on weight gain in clinical populations or on weight loss strategies, or the participants were outside the defined age range for this review. Another 13 potential studies were identified in Stage Two, five of which were retained. Therefore 29 studies were included in this review (see Figure 1).

The retrieved papers were sorted into one of four categories based on the behavioural determinant of weight gain addressed: contraception [17-20], dietary behaviours [21-23], quitting smoking [24], or physical activity (PA) [25]. Nine papers were allocated to one of these categories. The remaining 20 papers focussed on university populations [26-45]. Many of these papers did not provide a reason for weight gain other than 'university attendance'; others suggested multiple concurrent reasons for weight gain and could not be allocated to one of the four behavioural categories. These papers were, therefore, placed in a category of their own. As some of these 'university' papers included information about diet and PA, they were also included in the descriptive sections for these two behavioural determinants.

Contraception

Four of the 29 selected studies examined contraceptive use and weight gain, and of these, three reported weight gain. Details of the studies are shown in Table 1. Two assessed oral contraceptive use (OC) only, one assessed the effects of depot medroxyprogesterone acetate (DMPA) injection only and one study compared different forms of contraceptives (DMPA and Intra-Uterine Device (IUD)).

Neither of the two OC studies [18, 20] found significant changes in weight with OC use. Rosenberg [18] found that over 4 cycles, 52% of participants had no weight change (defined as <2lb change) and 28% gained more than 2lb. Lech & Ostrowska [20] also found no significant change in BMI after 6 cycles of OC use.

The DMPA study reported modest weight gain[19]. This study, carried out on behalf of the World Health Organisation (1986) with 1,216 women, found an average increase in weight of 0.37kg after 3 months DMPA use, equivalent to 1.48kg/yr[19]. However, only 14 women discontinued its use for this reason.

The comparison study of DMPA and Intra-Uterine Device (IUD) use (103 women in each group) confirmed these results[17]. During the 5 years of the study, DMPA users gained significantly more weight (4.3kg) than IUD users (1.8kg), however, the study did not control for PA, parity, smoking or other behavioural factors that may be associated with weight gain[17].

Reference	Study - number of women. - age - study duration - location - number of assessments	Type of contraception	Outcome measures	Weight Gain/Lost/Stable As concluded by authors	Authors Conclusions
			OC		
Lech M. and Ostrowska L. 2002[20]	- 700 - 24.37±5.95 yrs, 18-40 yrs - 6 cycles - Poland - 3 assessments	- OC	*Obj* - weight	Stable: - BMI pre: 21.0±2.7kg/m^2 - BMI after 6 cycles: 20.97±2.59 kg/m^2	- No significant changes in weight
Rosenberg M. 1998[18]	- 128 - 18-35 years - 4 cycles - USA - daily weighing	- OC	*S-R* - weight	Stable: - 52% no change (<2lb difference) - 28 % gained weight - 20% lost weight	- Little to no change in weight
			DMPA		
WHO 1986[19]	- 1216 - 27.7±5.0 yrs - 12 months - Egypt - 5 assessments	- DMPA (100mg or 150mg)	*Obj* - weight	Gain: - 0.37kg/3mths; equivalent to 1.48kg/yr (95%CI= 1.29, 1.66kg)	

				- No significant differences found between doses	
Comparison study					
Bahamondes L., *et al.* 2001[17]	- 206 - 33.1±0.7 yrs - 5 yrs - Brazil - 6assessments	- DMPA (150mg) - IUD	*Obj* - weight	Gain: -DMPA: 4.3 kg over 5 yrs ($p \leq 0.05$) -IUD: 1.8kg over 5 yrs($p \leq 0.05$)	- DMPA users gained significantly more weight than the IUD users, this increase became significant after 2 yrs - age associated weight gain thought to be a factor

BMI- Body mass index: BMI ≤ 18.5 = underweight; 18.5-24.9 – normal; 25-29.9 – overweight (ov); > 30 = obese (ob) (unless otherwise stated); DMPA – Depot Medroxyprogesterone Acetate; IUD – Intra-Uterine device ; kg – kilograms; Obj- Objective Measures; OC- Oral Contraceptive; SD – Standard Deviation; S-R- Self- Report Measures; WG- Weight gain; wks – weeks; yrs – years;

Table 1: Summary of the studies describing weight change with contraception use

Dietary behaviours

Three US longitudinal observational studies examined the role of eating or dietary behaviour on weight change [21-23]. See table 2 for details of these studies.

Two of the three studies examined self-reported fast-food consumption [22, 23] and found that this was associated with weight gain. For example, in one study, weight gain in those who ate one fast-food meal per week was 0.72 kg above the average weight gain over a period of three years [23]. The Coronary Artery Development in Young Adults (CARDIA) study [22], which assessed dietary habits in 1,580 women, aged 18-30 at baseline, found that change in fast-food habits over 15 years was independently associated with changes in weight. Frequent fast food intake was associated with an extra 4.5kg gain over 15 years and was associated with a two-fold increase in insulin resistance [22]. Both studies that assessed fast-food intake found this to be associated with an additional 0.24[23]- 0.3[22] kg/yr above average weight gain.

The third study was part of the Nurses' Health Study II [21]. The researchers distinguished between different types of diet: a 'western' diet (high in red and processed meat, refined grains, potatoes, sweets and desserts); a 'prudent' diet (high in fruit and vegetables, whole grains, fish and poultry); or a combination of the two. They examined changes in individual diets and associations with weight change over an 8 year period in 51,610 women aged 26-44 years at baseline. The western diet was associated with an average weight gain of 7.81kg over eight years, whereas women who sustained a high prudent score were more likely to maintain their weight [21].

The associations between weight gain and diet were also considered in some of the university studies. Seven of those studies [26, 27, 29, 36, 37, 40, 41] suggested that diet quality was a predictor of weight gain, with inadequate consumption of fruit and vegetables [27, 29, 36, 40, 41], low fibre [26] and high fat/cholesterol [26, 27, 37] diets being commonplace amongst the students. Of these seven studies, five measured diet/dietary changes using a dietary behaviour questionnaire [26, 29, 37, 40, 41], while two measured diet using a food frequency questionnaire (FFQ) [27, 36]. The use of the FFQ allowed one study to report changes in caloric intake[27]. In that study, while average caloric intake decreased by 349 kcal/day over the five month period, consumption of alcohol and percent fat intake increased, and fruit and vegetable intake decreased [27]. Despite the decrease in caloric intake there was an overall weight increase of 0.73 kg; decreasing physical activity was purported to be the main contributor to this weight gain.

Reference	Study - number of women - age - duration - location - number of assessments	Measurement	Weight gain/Outcomes	Conclusions
Schulze M., *et al.* 2006[21]	- 51,670 - 26-44 yrs - 8 yrs 1991-99 - USA - Nurses' Health Survey II, 3 assessments	<u>*S-R*</u> - weight, height, dietary assessment - prudent vs western pattern	High western diet 5.62kg Low western diet 4.90kg Increased western 7.81kg Decreased western 4.04kg Increased prudent 3.75kg Decrease prudent 7.98kg All values significant ($p \leq 0.001$)	- decreases in prudent score over time were associated with significant increases in weight
Pereira M., *et al.* 2005[22]	- 1580 - 25.1 ±3.6 yrs, 18-30 yrs - 15 yrs 1985/6-2000/1 - USA - CARDIA study 6 assessments	<u>*Obj*</u> - weight, height, WC, insulin and glucose concentrations <u>*S-R*</u> - PA history questionnaire - Dietary assessment	Frequent f-f consumers at baseline and follow up: - extra +4.5kg WG ($P<0.05$) - two-fold greater increase in insulin resistance	- change in f-f over 15 yrs was independently associated with changes in weight

French S., *et al.* 2000[23]	- 891 - 35 yrs; 20-45 years - 3 yrs - USA - POP Study, 4 assessments	<u>*Obj*</u> - weight, height <u>*S-R*</u> - dietary intake, - f-f use - PA - eating behaviours - smoking	- average WG +1.68kg (p=0.01) - an increase of 1 f-f meal per week was associated with an increase of 56kcal/day, 0.6% in fat energy/day and a WG of 0.72kg over 3 yrs, above average WG	- increases in f-f consumption were associated with higher fat and energy intake, greater body weight, higher intake of soft drinks, decreases in vegetable consumption, less restrained eating and fewer low-fat behaviours

BMI- Body mass index: BMI ≤ 18.5 = underweight; 18.5-24.9 – normal; 25-29.9 – overweight (ov); > 30 = obese (ob) (unless otherwise stated); f-f- fast food; kg – kilograms; mnths – months; Obj- Objective Measures; PA- Physical Activity; POP- Pound of Prevention study; S -R- Self Report Measures; WG- Weight gain; wks – weeks; yrs – years;

Table 2: Summary of the studies describing weight change with dietary behaviours

Smoking

Only one paper [24] reported on the association between weight gain and quitting smoking in women in this age group. The study was part of the European Community Respiratory Health Survey II, carried out in Germany. The researchers followed 3,368 women for an average of 8.9 years, with objective measures of weight. They reported that average weight gain was higher in quitters (0.78kg/yr) than in continuing smokers (0.42kg/yr), never smokers (0.53kg/yr) and re-starters (0.22kg/yr).

Activity

Only one [25] of the 29 papers assessed the relationship between leisure time physical activity (PA) and weight gain. This study was carried out as part of the CARDIA study. A group of 1,541 women completed 5 assessments over a 10 year period, with self-report measures of vigorous PA ($\geq$ 6 METS) and objective measures of weight. There was an inverse association between PA and weight change, with a stronger association in those who were overweight at baseline.

Changes in PA levels (increased, maintained or decreased) between years 2 and 5 and again between years 5 and 7 of the 10 year study period, were compared with body weight change. The majority of the participants maintained their activity level between 2 and 5 years and again between 5 and 7 years, and gained 1.1kg/yr; those who decreased their PA level and maintained this decrease, gained the same amount of weight, on average 1.08kg/yr; participants who increased and maintained their PA level had the smallest weight gain (0.37kg/yr). These women, however, comprised only 6% of the total sample.

Six of the university papers specifically associated a decline in PA levels with increases in weight [27, 30, 35, 36, 40, 41]. All papers used self-report measures of PA. Of these six papers, half based their questionnaires on the American College of Sports Medicine guidelines[36, 40, 41]. The questions asked about vigorous exercise (exercise that raises the heart rate or causes sweating) in bouts of at least 20 minutes on 3-5 days of the week[36, 40, 41]. Two papers considered physical activity of different intensities: mild, moderate and/or vigorous[30, 35]. Butler *et al.*[27] examined PA in different 'dimensions': work, sport, leisure time and total PA, in the previous 4 months. Three of the studies also included strength items in their questionnaires[30, 40, 41].

University

Over half the identified papers (20/29) [26-46] addressed weight gain whilst at university or during the transition from high school to university. Details of these studies are reported in Table 3. Eight studies included baseline and up to four follow-up measurements [30, 31, 33-35, 41, 43, 44]. The average number of women in each study was 94, with a range of 22[31] to 256 [29]. Four studies included <50 women [31, 32, 42, 46] eight studies included 50-100 women [26, 27, 34, 37, 38, 43-45] and eight studies included >100 women [28-30, 35, 36, 39-41]. Eighteen studies measured weight objectively and nine of those collected body composition data using Bioelectrical Impedance Analysis (BIA) [30-32, 35], Dual Energy X-ray Absorptiometry (DXA) [33, 34, 39] or skinfolds [26, 27]. Most of these studies also collected self-report data on PA [27, 30, 35-37, 39-41, 44] and dietary behaviours [26-31, 35-37, 42, 43].

The majority of these studies, 15 out of 20 [27-32, 34-39, 42, 43, 44], considered weight gain whilst students were in their first (freshman) year of university. The mean duration of these 15 studies was 6.7 months, ranging from 12 weeks [37] to 1 year [35]. Nineteen studies were carried out in the USA and one in Canada [30]. All except one observed an increase in weight, with two [36, 38] noting that the rate of weight gain was 5.5-6.7 times greater than that seen in the general population of American adults aged 18-74 years. Only one study found no significant change in weight over a one year period, but observed a wide variation in weight change, from a loss of 6.8kg (15lbs) to a gain of 6.8kg (15lbs), with 59% of the female students gaining weight[42].

In general, studies of women in their first year of university showed that women gained weight at a higher rate during the first semester than during later periods of their university career. For example, Levitsky *et al.* [37] reported a gain of 1.9kg over 12 weeks in the first semester. Canadian researchers, who examined the transition from high school to university in 116 women, reported a 2.4kg increase in weight from the summer prior to starting university to the end of first semester[30]. This rate of weight gain of 0.11kg/week between summer and autumn, however, declined to 0.06kg/week between autumn and winter. There was also a 2.5cm increase in waist circumference in this study [30]. Anderson *et al.* [44] also reported that weight gain was higher between September and December (first semester), than in the period December to March of first year at University (second semester).

Four papers reported weight gain over a longer period of time than the first year [26, 33, 40, 41]. Three studies assessed weight from the beginning of first year to the end of second

year [26, 33, 41]; all found an increase in weight over this time. Two of these studies [33, 41] examined weight at mid-points between pre- and post-assessments. Both found that the greatest weight gain occurred during the first year, which then tended to stabilise over the following year, with little extra weight being gained. One of these four studies was then continued for four years, and reported that 70% of students gained weight, with an average overall weight gain in women of 1.7 (SD 4.5) kg [40].

One study of 50 female US students, which assessed weight gain during the Thanksgiving holiday break, found that women gained an average of 0.4kg ($p < 0.05$) during this period (average duration 13±3 days). They also found that BMI was associated with weight gain, with overweight/obese participants gaining more weight than participants in the normal BMI category [45].

While several of the 19 studies reported weight gain at university without considering the reasons underlying it, [31, 32, 34, 38, 44, 45] or were unable to determine potential causes [28, 39, 43, 46], others were able to identify possible determinants of weight gain during the university years. These included: baseline weight/BMI [36]; decreasing PA [26, 27, 35, 40, 41]; poor quality diet with inadequate consumption of fruit and vegetables and increased high-fat foods [29, 36, 37, 40, 41]; increased alcohol consumption [26, 27]; high levels of academic workload and stress [29] and increased computer use [30]. Living accommodation was also shown to be important, with one study showing that higher weight gain occurred whilst living on-campus than when living off-campus [33].

Reference	Study -number of women -mean age ± SD and/ or range -duration -location -number of assessments	Measurements	Weight change: gain/lost/stable	Authors Conclusions
		First Year Studies		
Economos C., *et al.* 2008[29]	- 256 - 17.8 ± 0.5 yrs - 8-9 mths - USA - Pre/post	*Obj* - weight, height *S-R* - weight, height - health behaviour	Gain: mean ± SD - overall: + 5.5 ± 6.4lbs ($p \leq 0.001$) - gainers (80.9%): + 7.6 ± 5.0lbs ($pP \leq 0.001$)	- stress and academic workload are positively correlated with WG
Edmonds M., *et al.* 2008[30]	- 116 - 18.5 ± 0.6 yrs, 17-20 yrs - 7 mths transition from High school to university - Canada - 3 assessments	*Obj* - weight, height - BC using BIA - WC *S-R* - 24-hour diet recall - demographics - lifestyle	Gain: mean - overall: + 2.4 kg ($p<0.03$) - overall rate of WG ~ +110g/wk (summer-fall) ~ +60g/wk (fall-winter) - % ov increased from 15% to 22% - WC increased 2.5 cm	- changes in moderate PA was an important predictor of weight
Jung M., *et al.* 2008[35]	- 101 - 18.5 ± 0.6 yrs - 1 year - USA - 4 assessments	*Obj* (pre/post only) - weight, height - BC using BIA *S-R* - PA - food diary	Gain: mean ± SD - overall: + 3.08 ± 8.35 lbs - gainers (65%): + 7.54 ± 6.01 lbs ($p<0.001$) Loss: mean ± SD - losers (34%): -5.3 ± 5.26lbs*	- PA defining characteristic in freshman weight gain

Kasparek D., *et al.* 2008[36]	- 169 - 17-19 yrs - 6 mths - USA - Pre/post	<u>*S-R*</u> - weight, height - lifestyle and behavioural questionnaire - Physical activity	Gain: mean - overall: 2.5lbs ($p<0.05$) - gainers (57%): range 1-35 lbs - initially normal weight: + 6.21 ± 4.27 lbs - initially ov/ob: +10.96±8.30 lbs	- weight gain 6.7x greater than that expected for US adults - baseline BMI is a factor in WG
Mihalopoulos N., *et al.* 2008[38]	- 83 - 18.4 ± 0.5 yrs - 7 mths - USA - Pre/post	<u>*S-R*</u> - weight, height	Gain: mean - overall: + 1.7lbs (CI 0-3.5) ($p=0.09$) - gainers (51.3%): 7.5 lbs, range 5.6-9.4 lbs - rate of WG in weight gainers ~425g/mth Lost/stable: - 15% lost weight - 33% remained stable	- weight gain 5.5 times greater than in general population.
Delinsky S. and Wilson G. 2007[28]	- 149 - 17.9 ±0.5 yrs - 7 mths - USA - Pre/post	<u>*Obj*</u> - weight, height in randomly selected subgroup, n = 44: <u>*S-R*</u> - weight, height - dietary habits - self esteem - body shape	Gain: mean ± SD - overall: + 1.53 ± 3.4kg ($p<0.01$) -gainers (63%): + 3.3 ± 2.7kg -9 women gained >15lbs - % ov increased from 11.4% to13.4%	- 'Freshman 15' largely a myth, but significant weight gain seen in freshman year

Hull H., *et al.* 2007 [34]	- 69 - 18.3 yrs - 1 yr - USA - 3 assessments	<u>*Obj*</u> - weight, height - BC using DEXA	Gain: mean - +1.3kg over academic period - FFM increase of 0.5kg - significantly higher WG over academic period than the summer period (gain (mean): 0.1kg) - FFM decrease of 1.1kg over summer period ($p<0.01$)	- change in body composition – unfavourably over academic and summer periods
Hull H., *et al.* 2006[45]	- 50 - 21.8 ± 4.1 yrs - 13 ± 3 days (Thanksgiving) - USA - Pre/post	<u>*Obj*</u> - weight, height, waist and hip circumference	Gain: mean - 0.4kg ($p<0.05$) - correlation between BMI and weight gain ($r= 0.42$, $p<0.01$)	- Holiday season is creates a high risk environment for weight gain
Hajhosseini L., *et al.* 2006[31]	- 22 - 18.3 ± 0.02 yrs - 16 wks - USA - 3 assessments	<u>*Obj*</u> - weight, height - BC using BIA - RMR <u>*S-R*</u> - 3-day food intake diary	Gain: mean±SD - overall: + 3.0 ± 0.7 lbs ($p=0.001$) - 59% gain ≥3lbs, 22% ≥6lbs -BMI and FM increase ($p\leq0.002$) - FFM decrease ($p=0.001$)	- 3lb increase in 16weeks - this is equivalent to ~94kcal/day excess energy intake
Hoffman D., *et al.* 2006[32]	- 35 - Freshman - 7 mths - USA - Pre/post	<u>*Obj*</u> - weight, height - BC using BIA	Gain: mean±SD - overall: +1.28 kg± 2.74 - gainers: +2.67±1.73kg - BF: +0.8±4.8 % - FM: +1.17±2.95kg - BMI: +0.98±2.84 kg/m^2	- in weight gainers 112 kcal per day positive energy balance over the 7-month period - this is equivalent to 12.4kg gain by graduation if continued for the 4 years of college

Lowe M., *et al.* 2006[43]	- 69 - 18.1yrs - 8 mths - USA - 3 assessments	*Obj* - weight, height *S-R* - eating/dieting - weight and dieting history	Gain: mean - overall: +2.08kg - 83% gained weight within 1st month	- neither self report overeating or restrained eating predicted WG
Morrow M., *et al.* 2006[39]	- 137 - 18.2 ± 0.7 yrs, 18-20 yrs - 1 academic yr - USA - Pre/post	*Obj* - weight, height - WC - HC - BC using DEXA *S-R* - PA	Gain: mean±SD - overall: + 1.1 ± 2.7 kg ($p \leq 0.001$) - BMI, % fat, total fat, FFM, WC and HC increase*	- modest but significant increases in body weight and composition during first year at university - no significant changes in moderate or vigorous PA
Levitsky D., *et al.* 2004[37]	- 51 - 18.2 yrs - 12 weeks - USA - Pre/post	*Obj* - weight *S-R* - lifestyle and behavioural questionnaire	Gain: mean±SD - overall: +1.9 ± 2.4kg = ~+158.3g/week ($p \leq 0.01$) - BMI increase*	- WG greater than in general population - evening snacking and increased high-fat foods best predictors of weight gain
Butler S., *et al.* 2004[27]	- 54 - 17.8 yrs - 5 mths - USA - Pre/post	*Obj* - weight, height - BC using skinfolds - fitness assessment – VO2 max, recovery heart rate	Gain: mean - overall: +1.59lbs ($p \leq 0.01$) - BMI increase ($p \leq 0.01$) - fat increase of 1.79% ($p \leq 0.001$)	- decrease in PA seems to be the biggest contributor to WG

		S-R - diet by FFQ - PA - self-efficacy		
Anderson D., *et al*. 2003[44]	- 77: -Sept-Dec: 77 - Sept-May:29 - 17.9 ± 0.5 yrs - 3 mths - USA - 2 or 3 assessments	*Obj* - weight, height *S-R* - behaviour, diet, drugs and alcohol questionnaire	Gain: mean overall Sept-Dec: +1.3kg ($p<0.01$) - gainers (70%) - 26% gained >2.3kg, - ov/ob increase from 21% in Sept to 33% in Dec subgroup – Sept-May (mean): +1.7kg ($p<0.01$)	- WG occurs predominately at beginning of year as weight gain in the subgroup was significant from Sept- Dec, but NS from Dec-May.
Graham M., *et al.* 2002[42]	- 39 - 18.5 yrs - 1 academic yr - USA - Pre/post	*Obj* - weight, height - body fat *S-R* - eating attitudes	Gain: - gainers (59%): mean +4.6 lbs Stable: No significant weight change seen - overall (range): -15 to +15 lbs.	- no significant effects of transition to university on weight were seen.
		Longer duration studies		
Racette S., *et al.* 2008[40]	- 138 - 18 yrs - 4 yrs First yr through until end of senior yr - USA - Pre/post	*Obj* - weight, height *S-R* - diet behaviour - exercise	Gain: mean±SD Overall: +1.7 ± 4.5kg ($p<0.001$) - ov/ob increased from 15% to 23%* (M&F) - height increased ($p<0.001$) - BMI +0.5±1.6kg/m^2 ($p<0.001$)	weight gain during freshman year does not continue throughout university

Adams T. and Rini A. 2007[26]	- 66 - 18-31 - 2 yrs - USA - Pre/post	*Obj* - weight, height - BC using skinfold measurements *S-R* - weight, height - health behaviour	Gain: BMI-increase	- weight gain associated with: - alcohol consumption - maladaptive coping behaviours - caffeine intake - energy intake and dietary fibre
Hull H., *et al.* 2007 [33]	- 48 - 19.2 ± 0.4 yrs - 2 yrs First yr through to end of second yr - USA - 4 assessments	*Obj* - weight, height - BC using DEXA *S-R* - NA	Gain: mean first year: +1.2kg - FM +0.8kg Stable: Second year (mean) + 0.2kg	- Largest increase in weight in first year - Living on campus/off campus significant difference in BC – off campus more favourable changes to BC
Racette S., *et al.* 2005[41]	- 154 - 18.1 ± 0.3 yrs - 2 yrs Beginning of first yr to end of second yr (2 academic yrs) - USA - 2 or 3 assessments	*Obj* -weight, height *S-R* - diet - exercise	Gain: mean±SD overall: 1.8±5.2kg (p<0001) - gainers (70%): +4.1±3.6 kg subgroup – N=118 (66) measured during first year - +2.5±5.0kg (p<0.001) - 75% increased their BMI	PA and dietary behaviour not meeting recommendations may contribute to weight gain

BC- Body composition; BIA- Bioelectrical Impedance Analysis; BMI- Body mass index: BMI ≤ 18.5 = underweight; 18.5-24.9 – normal; 25-29.9 – overweight (ov); > 30 = obese (ob) (unless otherwise stated); DEXA- Dual Energy X-ray Absorpometry; FFM- Fat Free Mass; FM- Fat Mass; (gainers)- average for only those that gained weight; FFQ- food frequency questionnaire; HC- Hip circumference; kg- kilograms; lbs- pounds; M- Males; mths- months; NA- Not applicable; NS- Non-significant; Obj- Objective Measures; PA- Physical Activity; SD- Standard Deviation; S-R- Self- Report Measures; WC- Waist Circumference; WG- Weight Gain; wks – weeks; yrs – years; % Fat- Percentage Body Fat;

Table 3: Summary of the studies describing weight change in and transitions to University

Discussion

Twenty-nine papers were located that reported weight change in non-clinical non-pregnant female populations in the age range of 18-36 years, of which 27 studies reported weight gain. Weight gain was found to be associated with contraceptive use, dietary behaviour (fast-food intake and western style diet), quitting smoking, decreasing physical activity levels and university transition.

The majority (65%) of the studies in this review were carried out with university students. These papers showed the first semester of the first year at university was a critical time for weight gain[31, 37, 44]; an average gain of 1.5kg was gained over the first 3-4 months[31, 37, 44]), with only slightly higher rates seen at the end of the academic year (1.9kg over nine months[29, 39, 42]). However, little or no weight was gained in the subsequent years of study[40]. As many of these studies reported that weight gain at this life stage is determined by a cluster of behaviours including diet, physical activity, alcohol consumption and computer use, they were considered separately from the 'single determinant' papers included in this review. Most university studies attributed weight gain to dietary behaviour and decreasing/inadequate levels of PA [27, 35-37, 40, 41]. This is in line with the general notion that weight gain is the result of an underlying energy-balance problem [47]. Transition to university may evoke detrimental dietary and physical activity behaviours that lead to a larger imbalance between energy intake and energy expenditure. This may be a particular problem during the holiday season when cultural and social influences combine to create a high risk environment for weight gain[45, 48-50]. However, few of the University studies considered changes in other behavioural factors that were addressed in the ‘single’ determinant papers, such as smoking and contraceptive use.

The evidence for weight gain due to contraceptive use is varied. Several studies have now concluded that OC use does not seem to yield great weight gain. However, approximately 20% of participants in one study gained between 0.9 and 2.3kg (2-5lbs) in 4 cycles; the authors referred to this as "minimal gain" [18]. Another study of 54 undergraduate students, which was excluded as it was an intervention study, found an increase in weight of 1.3kg with 3 months of OC use [51]. If this rate of weight gain (approximately 430g/mth) continued, even for only 6 months, it would equate to approximately 2.6kg, which could be significant in terms of population health. None of the OC papers provided data on long term change.

DMPA use was associated with greater weight gain than other hormonal contraceptives. Reviews that have examined this issue have however been inconclusive, due to a lack of control information and variation in duration of studies [52]. Another study that examined the impact of DMPA on weight gain was located, however, it was part of a trial and therefore excluded from this review [53]. This paper reported the results of three trials conducted in the US and Europe, two of which were carried out for a year and the third for three years. The combined trials, which observed more than 2,300 women (aged 18-35), reported modest weight gain (<2.3kg at 12 months) with large individual variation[53]. As studies that assessed only the first few months [18] of contraceptive use reported greater weight gain than those that examined changes over a longer period of time, [17] there may be some adjustment period, after which initial weight gain is discontinued or reduced. Although researchers are unsure of the true effects of contraception on weight, it is commonly cited as a primary reason for discontinuation of hormonal contraceptives [52].

Three papers in this review specifically addressed the associations between dietary behaviour and weight change; they concluded that dietary behaviours such as frequent fast-food intake and a western style diet are associated with weight gain. Many western style diets are low in fruit and vegetables, low in fibre and high in processed m**eats**. Furthermore, food prepared outside the home has been associated with higher calories, lower fibre, calcium and iron intakes [54], and hence with increased BMI [55] and reduced likelihood of weight maintenance (defined as remaining within 5% of baseline weight) [56]. Young adults have been shown to be the highest consumers of fast food [57], therefore making them a vulnerable group for weight gain.

Assessing the issue of quitting smoking was difficult, as only one paper with women in this age range was located. It reported that quitting smoking was associated with greater weight gain in quitters than in re-starters, continuing smokers and never smokers [24]. More papers were found, but as they focussed on older populations they were excluded from this review. The included paper raised the conundrum for health promotion workers that the adverse effects of weight gain may mask the health benefits of quitting smoking [24]. The need for controlling weight gain to get the full benefits of quitting is supported by Nilsson *et al,*[58] who examined the effect of smoking cessation on the impact of other biological factors. They found that increases in weight may adversely influence glucose tolerance, insulin resistance and lipid metabolism, negating some of the known positive benefits of smoking cessation. Women who want to quit smoking should be encouraged to be more active and limit their fast food intake, so that these adverse effects are minimised.

Surprisingly, only one paper specifically assessed the association between physical activity and weight gain. Other 'PA' papers either included older populations or did not report change in weight. However, the association between declining PA and increasing weight, observed by Schmitz *et al.* [25], is supported by the findings of some of the university papers [27, 30, 35, 36, 40, 41] and by the Amsterdam Growth and Health Longitudinal Study [59]. Independent of the association between physical activity and weight change, the association between sedentary behaviour and weight gain is becoming more prominent in obesity research [47]. One paper that focussed on *in*activity and weight gain was located; in it, Ball *et al.* [56] reported that an increase in sitting time was associated with a decreased likelihood of maintaining weight in young women. This paper was not included in this review as it did not report actual weight change.

The overall findings of this review confirm that young adulthood is a vulnerable time for weight gain. Unfortunately, most of the studies on weight gain in this population were descriptive and focused on the general 'lifestyle' of university, rather than the specific determinants of weight gain. Nonetheless, the results confirm that University students are at risk of weight gain. As 40% of young Australian adults now go to university[2], improved understanding of the relative contributions of the many lifestyle changes that occur at this life stage is now required, if effective strategies to prevent weight gain are to be developed.

The conclusions of a review are dependent on the quality of the included studies. Based on the criteria used by von Elm *et al.*[60], the overall quality of the papers included in this

review was relatively high. Source populations, recruitment methods and follow up data were described in all papers. However, many of the studies had relatively small numbers of participants; for example, all the university studies (range 22 [38]-256 [29] participants), and four of the contraception papers (range 128[18] - 206 [17]). However, all the papers on dietary behaviour (range 891[23] - 51,670 [21], the smoking paper [24] (N=3,368) and the PA paper [25] (N= 2,770) included more than 500 participants. All the papers that reported BMI measures defined the cut-off points used for overweight and obesity. Only four of the 28 papers included in this review used self reported weight data for their results; two of the University papers [36, 38], one contraception paper [18] and one paper on dietary behaviour [21]. Although all the diet papers, the PA and the smoking paper adjusted their results for potentially confounding demographic variables, only a few of the university studies [26, 29, 30, 37] reported results adjusted for demographic differences. This may be because the majority of the participants in these studies were of similar age, largely from Caucasian backgrounds and had a similar level of education, making adjustment for these factors unnecessary.

We acknowledge that this review has some limitations. Only one database (PubMed) was searched; other smaller searches were carried out with another database (Embase) but this did not result in additional papers that were not already identified in the PubMed search. For pragmatic reasons, only papers written in English were included, and this may have also limited our findings. As stated in the introduction, although it is accepted that pregnancy is associated with weight gain in young women [14, 15], publications in this area are limited by a lack of information on concurrent health behaviours which affect weight gain during and after pregnancy. Pregnancy-related weight gain was therefore

excluded from this search. It is acknowledged, however that pregnancy is one of the leading causes of weight gain for women at this life stage, [61] and it is likely that excess weight gained during pregnancy is directly associated with subsequent obesity [61].

Another limitation was that it was difficult to directly compare weight gain associated with the different determinants identified in this review, because weight gain was examined over different periods, and initial exposure to some determinants (e.g. starting a new contraceptive, going to University) was associated with higher rates of weight gain than prolonged exposure. More longer term studies are clearly required. Moreover, while there was a strong focus on university students, not all young women go to university. No studies were located that assessed weight gain in 'working women' in this age group. It is therefore difficult to know whether university related weight gain is comparable to weight gain in other groups of young women. This area is under-researched. Furthermore, as no studies have followed young women when they finish university and start full-time work, questions relating to weight change during the transition from University to full-time work remain unanswered.

Conclusion

The aim of this paper was to review the literature on non-pregnancy related determinants of weight gain in young women. Despite the documented high level of weight gain at this life stage, surprisingly few papers were found that focussed on determinants of weight gain in women aged 18-36. Most research in this area has focussed on the transition to and through university. More studies are needed to assess the concurrent contributions of multiple determinants of weight gain in this population group. Given the

known long term adverse health effects of overweight and obesity [6], more studies on weight gain and its determinants in non-university populations are required.

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